Demystifying Loads for Building Officials

Based on the 2024 IBC® and ASCE 7-22

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This 6-part webinar series will provide information to assist code officials during the plan review process on the proper evaluation of structural loads per the 2024 International Building Code® (IBC®) and the IBC-referenced 2022 ASCE/SEI 7 Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE 7-22). An overview of each topic along with changes that have occurred to the 2024 IBC and ASCE 7-22 will be provided as well as examples to show their application. The following topics will be presented:

- Load Path, Load Combinations and Risk Categories
- Dead, Live and Rain Loads
- Snow and Ice Loads
- Wind and Tornado Loads
- Earthquake Loads
- Flood and Tsunami Loads
- Temporary Structures

Understand proper evaluation of structural loads and associated criteria in the IBC and ASCE 7
Identify changes to load provisions and associated criteria in the 2024 IBC and ASCE 7-22
Describe examples to show application of provisions
Determine additional available resources

- Load Path, Load Combinations and Risk Categories
- Dead, Live and Rain Loads
- Snow and Ice Loads
- Wind and Tornado Loads
- Earthquake Loads
- Flood and Tsunami Loads
- Temporary Structures

Codes and Standards
**Intro**

**Structural Design Loads Changes**
- Updated loads
  - All environmental loads
  - Moving to risk basis
  - Guards and handrails
- Tornado loads – new
  - Risk Category III & IV

**Resources**
Available for use or that can be used for support or help

**IBC Significant Changes**

**Digital Codes Premium**
Intro

asce7hazardtool.online

- FREE
- Address or Lat/Long
- ASCE 7-10, 7-16 & 7-22
- Risk Category
- All environmental loads

Textbook with Solved Examples

- Figures, flow charts, design aids, and example problems
- Loads: dead, live, rain, snow, ice, wind (including tornado), earthquake, flood and tsunami

Webinar Series – ICC Learn Live

Demystifying Loads for Building Officials – 2024 IBC and ASCE 7-22

Topics in this series for 2024
- Load Path, Load Combinations and Risk Categories
- Dead, Live and Rain Loads
- Snow and Ice Loads
- Wind and Tornado Loads
- Earthquake Loads
- Flood and Tsunami Loads
- Temporary Structures

Handouts
COURSE OUTLINE

- Load Path
  - Gravity
  - Lateral
  - Uplift
- Load Combinations
  - LRFD/Strength Design
  - ASD
- Risk Categories

Load Path
Transferring building loads into the earth

Concentrated vs Uniform Loads

Gravity Load Path – Tributary Area
Gravity Load Path – Beam Spans

- 2 simple span beams
- Continuous multi-span beam

Gravity Load Path – Light Frame

Gravity Load Path – Frame/Purlin Systems

1. Gravity load on roof sheathing
2. Transfer to walls and roof purlins
3. Load travels to rigid frame or walls to foundation

Gravity Load Path – Slab/Beam/Column Systems

Structural Load Determination: 2024 IBC and ASCE/SEI 7-22
Gravity Load Path – Columns

Gravity Load Path – Foundation

Footings

Gravity Load Path – Foundation

Poles/piles

Gravity Load Path – Foundation

Helical Piles
**Gravity Load Path – Foundation**

- Deep
- Driven
- Cast-in-place

**Lateral Load Path**

**Lateral Load Path – Tributary Area**

**Building Systems**

- Braced Frame
- Moment Frame
- Bearing/Shear Wall
Load Path, Load Combinations, and Risk Categories

**Moment Frames – Steel**

**Shear Walls**
- Masonry
- Concrete

**Shear Walls**
- CFS Studs
- Wood Studs

**Lateral Load Path – Shear Walls & Diaphragms**
Load Path – Light-frame Roofs

Load Path – Light-frame Walls

Some connectors resist both lateral and shear loads.

Load Path – Light-frame Shear Walls

- Roof or floor diaphragm collects loads
- Top plates "drag" load to shear walls
- Shear walls resist shear and overturning and transfer load to foundations

Seismic Load Path – Light-frame Shear Wall

- Shear Walls
- Top plate collector
- Wood Structural Panel (WSP)

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Wind Load Path – Light-frame Shear Wall

- Nails
- Wood Structural Panel (WSP)
- 2x4 or 2x6 Framing
- Top Plates
- Bottom (Sill) Plate
- Anchor Bolt (with plate washers)
- Hold-downs
- Shear Wall

Load Path – Light-frame on Foundations

Some connectors resist both lateral and shear loads

Lateral Load Path – Commercial Roofs

- High load roof diaphragms on tilt-up buildings

1604.4 Rigid vs Flexible Diaphragms

- Envelope analysis – rigid and flexible separately
- Design components for most severe condition

CODE CHANGE

IBC § 1604.4
ASCE 7-22 12.3
4. Wind load path in light frame construction needs to be considered in which direction(s)?
   a. Lateral
   b. Shear
   c. Uplift
   d. All of the above

Irregular Buildings

Seismic Design

Regular

Irregular

Load Combinations

Accounting for improbability of simultaneous maximum live loads

Symbols

\[ D = \text{Dead load} \]
\[ L = \text{Live load} \]
\[ L_r = \text{Roof live load} \]
\[ R = \text{Rain load} \]
\[ S = \text{Snow load} \]
\[ W = \text{Load due to wind pressure} \]
\[ W_T = \text{Load due to tornado pressure} \]
\[ E = \text{Combined effect of horizontal and vertical earthquake induced forces} \]

Note: Other loads such as ice, flood, and soil not shown
Load Combinations – ASD vs SD/LRFD

- ASD = allowable stress design
  - aka: working stress design
- SD = strength design
  - aka: LRFD
  - Concrete and masonry design
- LRFD = load and resistance factor design
  - Wood and steel design

Load Combinations – What’s the Point?

What’s the probability of 100% snow load AND 100% floor live load?

Example Load Combinations

LRFD: 1.2D + 1.6L + 0.3S
ASD: D + 0.75L + 0.525S

Load Combinations – LRFD/Strength Design (SD)

- 1.4D
- 1.2D + 1.6L + (0.5L, or 0.3S, or 0.5R)
- 1.2D + (1.6L, or 1.0S, or 1.6R) + (L or 0.5W)
- 1.2D + 1.0(W or WT) + L + (0.5L, or 0.3S, or 0.5R)
- 0.9D + 1.0 (W or WT)
- 1.2D + E_v + E_h + L + 0.15S
- 0.9D − E_v + E_h

Load combinations account for the improbability of simultaneous maximum live loads

CODE CHANGE
Load Combinations – ASD

- \( D \) (Eq 1a)
- \( D + L \) (Eq 2a)
- \( D + (L, \text{ or } 0.75 \text{ or } R) \) (Eq 3a)
- \( D + 0.75L + 0.75(L, \text{ or } 0.75 \text{ or } R) \) (Eq 4a)
- \( D + 0.6(W \text{ or } W_T) \) (Eq 5a)
- \( D + 0.75L + 0.75(0.6(W \text{ or } W_T)) + 0.75(L, \text{ or } 0.75 \text{ or } R) \) (Eq 6a)
- \( 0.6D + 0.6(W \text{ or } W_T) \) (Eq 7a)

- \( D + 0.7E_v + 0.7E_h \) (Eq 8)
- \( D + 0.525E_v + 0.525E_h + 0.75L + 0.1S \) (Eq 9)
- \( 0.6D − 0.7E_v + 0.7E_h \) (Eq 10)

Load Combinations – Alternative ASD

- \( D + L + (L, \text{ or } 0.75 \text{ or } R) \) (Eq 16-1)
- \( D + L + 0.6W \) (Eq 16-2)
- \( D + L + 0.6W + 0.7S/2 \) (Eq 16-3)
- \( D + L + 0.7S + 0.6W/2 \) (Eq 16-4)
- \( D + L + 0.7S + E/1.4 \) (Eq 16-5)
- \( 0.9D + E/1.4 \) (Eq 16-6)

Where design for tornado loads is required, the alternative allowable stress design load combinations of Section 1605.2 shall not apply when tornado loads govern the design.

Risk Categories
Building classification based on hazard to life for determining load magnitudes

6. Load combinations account for the improbability of simultaneous maximum live loads?
   a. True
   b. False
Risk Category (RC)

- I – Low hazard to human life
- II – Ordinary buildings (not RC I, III or IV)
- III – Substantial hazard to human life
- IV – Essential facilities

IBC § 1604.5
ASCE 7 § 1.5

ASCE 7-22 Risk Categories

2024 IBC Risk Categories

No changes to RC I & II

2024 IBC Risk Categories

Moved to RC IV

CODE CHANGE

Risk Category | Nature Of Occupancy
--- | ---
III | Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to:
- Group I-2, Condition 1 occupancies with 50 or more care recipients.
- Group I-2, Condition 2 occupancies not having emergency surgery or emergency treatment facilities.
- Group I-3, Condition 1 occupancies.
- Any other occupancy with an occupant load greater than 5,000.
- Power-generating stations with individual power units rated 75 MWAC (megawatts, alternating current) or greater, water treatment facilities for potable water, wastewater treatment facilities and other public utility facilities not included in Risk Category IV.

a. For purposes of occupant load calculation, occupancies required by Table 1004.5 to use gross floor area calculations shall be permitted to use net floor areas to determine the total occupant load. The floor area for vehicular drive aisles shall be permitted to be excluded in the determination of net floor area in parking garages.
Free standing parking garages not used for the storage of emergency services vehicles, and not providing means of egress for buildings or structures assigned to a higher risk category, shall be assigned to Risk Category II.

- Most parking garages now RC II
- Can exclude drive aisles in net area calcs

Power generating stations
- No IBC definition
- 75 MWAC established as smallest power-producing unit
- Risk Category III

Buildings and other structures designated as essential facilities and buildings where loss of function represents a substantial hazard to occupants or users, including but not limited to:

- Group I-2 occupancies, Condition 2 occupancies having emergency surgery or emergency treatment facilities.
- Group I-3 occupancies other than Condition 1.
- Public utility facilities providing power generation, potable water treatment, or wastewater treatment.

Institutional Occupancy
- RC III
- RC IV

<table>
<thead>
<tr>
<th>Institutional Occupancy</th>
<th>RC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2 24-hr medical care for 6+ persons incapable of self-preservation</td>
<td>III x</td>
</tr>
<tr>
<td>1-3 Prisons/jails/detention for 6+ persons</td>
<td>x</td>
</tr>
<tr>
<td>Condition 1 – self-preservation capability</td>
<td>x</td>
</tr>
<tr>
<td>Other than Condition 1</td>
<td>x</td>
</tr>
</tbody>
</table>
2024 IBC Risk Categories

RC IV
- Essential facilities
- Buildings where loss of function represents a substantial hazard to occupants or users
- Public utility facilities providing power generation, potable water treatment, or wastewater treatment

Credit: www.greshamsmith.com
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IBC Table 1604.5

CODE CHANGE

2024 IBC Risk Categories

- Photovoltaic (PV) system definitions
- Ground-mounted PV system
  - Independent system without useable space underneath
  - Installed directly on the ground
- Elevated PV system
  - Independent support structure designed with useable space beneath
    - Minimum clear height of 7.5 feet
  - Intended for secondary use
    - e.g. vehicle shade or parking

Credit: www.greshamsmith.com
Public Domain - Wikimedia

IBC § 202

CODE CHANGE

2024 IBC Risk Categories

Photovoltaic (PV) panel Systems

<table>
<thead>
<tr>
<th>PV Systems &amp; Elevated PV Support</th>
<th>Risk Category (RC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>1 Ground mounted for Group R-3 only</td>
<td>x</td>
</tr>
<tr>
<td>2 Ground mounted other than 1 &amp; 5</td>
<td></td>
</tr>
<tr>
<td>3 Elevated other than 4, 5 &amp; 6</td>
<td></td>
</tr>
<tr>
<td>4 Rooftop and elevated PV on top of buildings</td>
<td>Same as building RC</td>
</tr>
<tr>
<td>5 Paired with ESS &amp; dedicated backup for RC IV building</td>
<td>x</td>
</tr>
<tr>
<td>6 Elevated &amp; used for emergency vehicle parking</td>
<td></td>
</tr>
</tbody>
</table>

Credit: www.greshamsmith.com
Public Domain - Wikimedia

IBC § 1604.5.2

CODE CHANGE

Importance Factor

<table>
<thead>
<tr>
<th>Risk Category from Table 1.5-1</th>
<th>Snow $I_s$</th>
<th>Ice—Thickness $I_t$</th>
<th>Ice—Wind $I_w$</th>
<th>Seismic $I_e$</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.80</td>
<td>0.80</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>II</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>III</td>
<td>1.10</td>
<td>1.15</td>
<td>1.00</td>
<td>1.25</td>
</tr>
<tr>
<td>IV</td>
<td>1.20</td>
<td>1.25</td>
<td>1.00</td>
<td>1.50</td>
</tr>
</tbody>
</table>

- Importance factors eliminated for snow and ice since values are now provided for each risk category
- Seismic system reliabilities are different from those for other environmental hazards

Credit: www.greshamsmith.com
Public Domain - Wikimedia

IBC § 1604.5.2

CODE CHANGE
7. Risk category descriptions are not the same in the IBC as in ASCE 7. Which governs?
   a. IBC
   b. ASCE 7
   c. Use whichever one you want
   d. Flip a coin

Load Path – transferring building loads into the earth
Load Combinations – accounting for improbability of simultaneous maximum live loads
Risk Categories – building classification based on hazard to life for determining load magnitudes
IBC 2024 loads’ changes consistent with ASCE 7-22

Resources
Available for use or that can be used for support or help

code UPDATES
2024 IBC Significant Structural Changes
- Part 5: Structural Design (Ch 16) Risk Categories
- Part 6: Structural Design (Ch 16) Loads

structuremag.org – March & April 2024
COURSE OUTLINE

Construction Documents

dead loads
live loads
rain loads

Construction Documents
Describing project elements to obtain a building permit

Dead Loads
Weight of materials to produce most severe load effect

Construction Documents

- Floor live load
  - Live load reductions
- Roof live load
- Special loads
  - Machinery/equipment
  - Greater than floor/roof loads
  - PV panel system dead loads
- Rain load data
  - Intensity
  - Drain, scupper and overflow locations
Dead Loads

- Weights of
  - Construction materials
  - Walls
  - Floors
  - Roofs
  - Ceilings
- Fixed service equipment
  - MEP
  - Tanks
- Photovoltaic panels
- Vegetative and landscaped roofs

Dead Load – PV System

- Photovoltaic panels
  - Panel systems
  - Support system
  - Ballast

Dead Load – Vegetative/Landscaped Roof

- Vegetative and landscaped roofs
  - Landscaping and hardscaping
  - Fully saturated soil
  - Fully dry soil
  - Most severe load effects

APPLICATION

4. Assuming a fully saturated soil will always produce the most severe load effect on a landscaped roof?
   a) True
   b) False
Live Loads
Produced by use and occupancy not construction/environmental

<table>
<thead>
<tr>
<th>Subject</th>
<th>2024 IBC</th>
<th>2021 IBC</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform</td>
<td>1607.3</td>
<td>1607.3</td>
<td>Reorg</td>
</tr>
<tr>
<td>Partial Loading of Floors</td>
<td>1607.3.1</td>
<td>1607.13</td>
<td>Reorg</td>
</tr>
<tr>
<td>Partial Loading of Roofs</td>
<td>1607.3.2</td>
<td>1607.14</td>
<td>Reorg</td>
</tr>
<tr>
<td>Partitions</td>
<td>1607.5</td>
<td>1607.5</td>
<td>Reorg and ASCE 7-22</td>
</tr>
<tr>
<td>Helipads</td>
<td>1607.6</td>
<td>1607.6</td>
<td>Reorg and revise</td>
</tr>
<tr>
<td>Heavy Vehicle</td>
<td>1607.8</td>
<td>1607.8</td>
<td>Emergency vehicles</td>
</tr>
<tr>
<td>Handrails and Guards</td>
<td>1607.9</td>
<td>1607.9</td>
<td>ASCE 7-22</td>
</tr>
<tr>
<td>Fixed Ladders</td>
<td>1607.10</td>
<td>1607.17</td>
<td>Renumbered</td>
</tr>
<tr>
<td>Vehicle Barriers</td>
<td>1607.11</td>
<td>1607.10</td>
<td>Renumbered</td>
</tr>
<tr>
<td>Impact</td>
<td>1607.12</td>
<td>1607.11</td>
<td>Renumbered</td>
</tr>
<tr>
<td>Reduction Uniform LL</td>
<td>1607.13</td>
<td>1607.12</td>
<td>Renumbered</td>
</tr>
<tr>
<td>Alternate ULL Reduction</td>
<td>1607.13.2</td>
<td>1607.12.2</td>
<td>Reorg</td>
</tr>
</tbody>
</table>

Concentrated vs Uniform Loads

2x10 REQUIRED
12 FEET

2x6 REQUIRED
12 FEET
The live loads used in the design of buildings and other structures shall be the maximum loads expected by the intended use or occupancy but shall not be less than the minimum uniformly distributed live loads given in Table 1607.1. Live loads acting on a sloping surface shall be assumed to act vertically on the horizontal projection of that surface.

- Moved from 1607.14

### Minimum Live Loads

<table>
<thead>
<tr>
<th>OCCUPANCY OR USE</th>
<th>UNIFORM (psf)</th>
<th>CONCENTRATED (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15. Garages and vehicle floors</td>
<td></td>
<td>See § 1607.7</td>
</tr>
<tr>
<td>Passenger vehicles only garages</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Trucks and buses</td>
<td></td>
<td>See § 1607.8</td>
</tr>
<tr>
<td>Fire trucks and emergency vehicles</td>
<td></td>
<td>See § 1607.8</td>
</tr>
<tr>
<td>Forklifts and movable equipment</td>
<td></td>
<td>See § 1607.8</td>
</tr>
<tr>
<td>17. Helipads</td>
<td></td>
<td>See § 1607.6.1</td>
</tr>
<tr>
<td>Helicopter takeoff weight 3,000 lb or less</td>
<td>40</td>
<td>See § 1607.6.1</td>
</tr>
<tr>
<td>Helicopter takeoff weight more than 3,000 lb</td>
<td>60</td>
<td>See § 1607.6.1</td>
</tr>
</tbody>
</table>

- Primarily reformatting

### Minimum Live Loads

<table>
<thead>
<tr>
<th>OCCUPANCY OR USE</th>
<th>UNIFORM (psf)</th>
<th>CONCENTRATED (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25. Public restrooms</td>
<td>Same as live load for area served but not required to exceed 60 psf</td>
<td>–</td>
</tr>
</tbody>
</table>

- Remaining sections renumbered
In office buildings and in other buildings where partition locations are subject to change, provisions for partition weight shall be made, whether or not partitions are shown on the construction documents, unless the specified live load is 80 psf or greater. The partition load shall not be less than a uniformly distributed live load of 15 psf and shall not be reduced per Section 1607.13. Exception: A partition live load is not required where the minimum specified live load is 80 psf or greater.

- Consistent with ASCE 7-22 § 4.3.2
- Partition live loads are not reducible
  - Can be relocated and clustered differently

Emergency vehicle loads need not be assumed to act concurrently with other uniform live loads.

- Consistent with ASCE 7-22 new section §4.10.4
- Operating loads
- Wheel and outrigger reactions
- Outriggers up to 60,000 lb

Handrails and Guards

- Consistent with ASCE 7-22 § 4.5
- 50 psf uniform load
- Not concurrent with 200 lb concentrated load
- Does not apply to unoccupiable roofs

5. For handrails and guards, the 50 psf uniform load is assumed to act concurrently with the 200 lb concentrated load?
   a. True
   b. False
Rain Loads
Rainfall rates are now based on building risk category

- Intensity based on 15-min duration storms for secondary drains
- Return period based on Risk Category
- Ponding provisions updated consistent with ASCE 7-22

Design Rain Load
Each portion of a roof shall be designed to sustain the load of rainwater as per the requirements of Chapter 8 of ASCE 7. Rain loads shall be based on the summation of the static head, $d_s$, hydraulic head, $d_h$, and ponding head, $d_p$, using Equation 16-19. The hydraulic head shall be based on hydraulic test data or hydraulic calculations assuming a flow rate corresponding to a rainfall intensity equal to or greater than the 15-minute duration storm with return period given in Table 1611.1. Rainfall intensity shall be determined in inches per hour for 15-minute duration storms for Risk Category given in Table 1611.1. The design rainfall shall be based on the 100-year 15-minute duration event, or on other rainfall rates determined from approved local weather data. Alternatively, a design rainfall of twice the 100-year hourly rainfall rate indicated in Figures 1611.1(1) through 1611.1(5) shall be permitted. The ponding head shall be based on structural analysis as the depth of water due to deflections of the roof subjected to unfactored rain load and unfactored dead load.

Design Process for Rain Loads

<table>
<thead>
<tr>
<th>Step</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Determine the rainfall intensity, $i_r$ for the Risk Category given in IBC Table 1611.1</td>
</tr>
<tr>
<td>2</td>
<td>Determine the flow rate, $Q$</td>
</tr>
<tr>
<td>3</td>
<td>Obtain the static head, $d_s$</td>
</tr>
<tr>
<td>4</td>
<td>Determine the hydraulic head, $d_h$</td>
</tr>
<tr>
<td>5</td>
<td>Determine the ponding head, $d_p$</td>
</tr>
<tr>
<td>6</td>
<td>Determine the design rain load, $R$</td>
</tr>
</tbody>
</table>

Adapted from Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill
Dead, Live and Rain Loads

Rain Loads

\[ R = 5.2(d_s + d_h + d_p) \] (IBC Equation 16-20)

- **R** – rain load on undeflected roof
- **d_s** – static head
- **d_h** – hydraulic head
- **d_p** – ponding head

Undeflected roof

§ 1611.1

---

CODE CHANGE

Secondary drainage system for structural loading (SDSL)
- Roof drainage system through which water is drained when primary drainage system blocked
- SDSL > 2” above primary drain

---

CODE CHANGE

Existing IBC rainfall maps deleted
- Intensity based on risk category
- ASCE Hazard Tool
  - Free resource for determining rain load
  - 15-min and 60-min intensities

**IBC Table 1611.1 Design Storm Return Period by Risk Category**

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Design Storm Return Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>I &amp; II</td>
<td>100 years</td>
</tr>
<tr>
<td>III</td>
<td>200 years</td>
</tr>
<tr>
<td>IV</td>
<td>500 years</td>
</tr>
</tbody>
</table>

---

EXAMPLE

- Cedar Rapids, IA
- Risk Category IV building
- 5,000 ft² tributary area
  - Primary
    - 4.24 in/hr (60 min, 500-yr)
  - Secondary
    - 8.71 in/hr (15 min, 500-yr)
- Calculate primary and secondary drain size and resulting rain load, R

asce7hazardtool.online
### Rain Loads – Risk Category Comparison

**Cedar Rapids, IA Example**

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Rate (in/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15-min</td>
</tr>
<tr>
<td>I &amp; II</td>
<td>6.90</td>
</tr>
<tr>
<td>III</td>
<td>7.66</td>
</tr>
<tr>
<td>IV</td>
<td>8.71</td>
</tr>
</tbody>
</table>

**Example**

- **Rain Load – Primary Drain**
  - IPC Table 1106.2
  - 5” vertical pipe or
  - 6” horizontal drain
  - 1/16” per foot min. slope

- **Rain Load – Primary Drain**
  - Q = 0.0104 x A x i (ASCE 7-22 Eq C8.2-1*)
  - where:
    - Q = flow rate for drainage > rainfall rate
    - A = tributary area = 5,000 ft²
    - i = water depth = 4.24 in/hr (60 min, 500-yr)
  - Q = 0.0104 x 5,000 ft² x 4.24 in/hr = 221 gal/min
  - *0.0104 factor converts area (ft²) and rainfall rate (in/hr) to gal/min

---

**Example**

- **Rain Load – Primary Drain**
  - IPC Table 1106.2
  - 5” vertical pipe or
  - 6” horizontal drain
  - 1/16” per foot min. slope

- **Rain Load – Primary Drain**
  - Q = 0.0104 x A x i (ASCE 7-22 Eq C8.2-1*)
  - where:
    - Q = flow rate for drainage > rainfall rate
    - A = tributary area = 5,000 ft²
    - i = water depth = 4.24 in/hr (60 min, 500-yr)
  - Q = 0.0104 x 5,000 ft² x 4.24 in/hr = 221 gal/min
  - *0.0104 factor converts area (ft²) and rainfall rate (in/hr) to gal/min

---

**Example**

- **Rain Load – Primary Drain**
  - IPC Table 1106.2
  - 5” vertical pipe or
  - 6” horizontal drain
  - 1/16” per foot min. slope
Rain Load – Secondary Drain

- \( Q = 0.0104 \times A \times i \) (ASCE 7-22 Eq C8.2-1*)
- where:
  - \( Q \) = flow rate for drainage > rainfall rate
  - \( A \) = tributary area = 5,000 ft²
  - \( i \) = 8.71 in/hr (15 min, 500-yr)
- \( Q = 0.0104 \times 5,000 \text{ ft}^2 \times 8.71 \text{ in/hr} = 453 \text{ gal/min} \)

*0.0104 factor converts area (ft²) and rainfall rate (in/hr) to gal/min

EXAMPLE

Rain Load – Secondary Drain

- \( d_s \) (static head) = 3"
  - specified distance from roof surface to bottom of scupper ≥ 2"
- \( R = 5.2(d_s + d_h) \) (IBC Eq 16-19*)
- \( R = 5.2(3" + 4") = 36.4 \text{ psf} \)

*Water density (62.5 pcf)/(12 in/ft) = 5.2 psf/inch of water depth

Are we done?

EXAMPLE

Rain Load – Secondary Drain

- \( d_p \) (ponding head) = 1" (iterative analysis)
  - Water depth due to roof deflections with unfactored rain load, \( R \), and unfactored dead load, \( D \)
- \( R = 5.2(d_s + d_h + d_p) \) (IBC Eq 16-19*)
- \( R = 5.2(3" + 4" + 1") = 41.6 \text{ psf} \)

*Water density (62.5 pcf)/(12 in/ft) = 5.2 psf/inch of water depth
Rain Loads Supplemental Data Request

<table>
<thead>
<tr>
<th>References*</th>
<th>Secondary Drain (SDSL) Parameters</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBC 1604.5</td>
<td>Building Risk Category: I, II, III, IV</td>
<td>IV</td>
</tr>
<tr>
<td>ASCE 7 CIK-2-1</td>
<td>Tributary area, A (sq ft)</td>
<td>5,000</td>
</tr>
<tr>
<td>ASCE 7 CIK-2-2</td>
<td>15 min rainfall intensity, i (in./hr)</td>
<td>8.71</td>
</tr>
<tr>
<td>ASCE 7 CIK-2-2</td>
<td>Flow rate, Q (gpm)</td>
<td>453</td>
</tr>
<tr>
<td>IBC 1611.1</td>
<td>Static head, dh (in.)</td>
<td>3</td>
</tr>
<tr>
<td>IBC 1611.1 Commentary</td>
<td>Hydraulic head, dh (in.)</td>
<td>4</td>
</tr>
<tr>
<td>Per design</td>
<td>Ponding head, dh (in.)</td>
<td>1</td>
</tr>
<tr>
<td>IBC 1611.1</td>
<td>Design rain load, R (psf)</td>
<td>41.6</td>
</tr>
</tbody>
</table>

*IBC 2024 and ASCE 7-22

---

### Ponding Instability

Free-draining bays and internal bays not subjected to accumulated rain load required by Section 8.2 shall have adequate strength and stiffness to preclude progressive deflection (i.e., instability) and resist potential ponding rain loads where either of the following conditions are met:

1. The roof slope is less than 1/4 in. per foot (1.19 degrees), or
2. The bay is adjacent to a free-draining edge with secondary members parallel to the free-draining edge and the roof slope is less than \( \beta \) where \( \beta = (L_s/S + \pi)/20 \) (in. per foot).

---

### Ponding Instability – Secondary Members

May require additional investigation in accordance with ASCE/SEI H8.3 depending on the roof slope (typ).

\[ L_s = \text{secondary member span} \]
\[ S = \text{secondary member spacing} \]
\[ \beta = \text{specified roof slope} \]
Ponding Instability

- Primary member span, \( L_p \)
- Secondary member span, \( L_s \)
- Specified roof slope, \( \beta \)

Example:

Ponding Instability

- Is roof susceptible to ponding?
- Assume free-draining edges
- Secondary members \( \parallel \) edge
- \( \beta = 0.5"/\text{ft} \)
- \( L_s = 35' \)
- \( S = 5' \)

\[
\frac{1}{20} (\pi + \frac{L_s}{S}) = \frac{(3.14 + 35/5)}{20} = 0.51"
\]

- 0.51" > 0.5" \( \rightarrow \) susceptible
- Additional investigation required

Ponding Instability Supplemental Data Request

<table>
<thead>
<tr>
<th>Reference</th>
<th>Ponding Instability Parameters (IBC 1611.2)</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASCE 7 § 8.3</td>
<td>Roof slope &lt; ( \frac{3}{8} &quot; ) per foot? If yes, additional investigation required</td>
<td>No</td>
</tr>
<tr>
<td>ASCE 7 Eq C8.3-2</td>
<td>Secondary members parallel to free-draining edge?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Secondary member span, ( L_s ) (ft)</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Secondary member spacing, ( S ) (ft)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Specified slope, ( \beta ) (in./ft)</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>Calculated slope comparison (in./ft)</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td>If ( \beta ) &lt; calculated value, then additional investigation required</td>
<td>Yes</td>
</tr>
<tr>
<td>ASCE 7 Eq C8.3-1</td>
<td>Secondary members perpendicular to free-draining edge?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Secondary member span, ( L_s ) (ft)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Primary member span, ( L_p ) (ft)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Specified slope, ( \beta ) (in./ft)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Calculated slope comparison (in./ft)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If ( \beta ) &lt; calculated value, then additional investigation required</td>
<td></td>
</tr>
</tbody>
</table>

Application

6. Rainfall intensity for a secondary drain system is based on which of the following durations?

a) 15-minute
b) 30-minute
c) 45-minute
d) 60-minute
Dead Loads – weight of materials to produce most severe load effect

Live Loads – produced by use and occupancy not construction or environmental (significant reorg)

Rain Loads – rainfall rates are now based on building risk category and new ponding instability provisions in ASCE 7-22

IBC 2024 loads’ changes consistent with ASCE 7-22

Resources
Available for use or that can be used for support or help

IBC Plan Review Record
### Snow Loads

Ground snow loads are now based on risk category.

**Definitions**

- **GROUND SNOW LOAD GEODATABASE**: The ASCE database (version 2022-1.0) of geocoded values of risk-targeted design ground snow load values.
- **GROUND SNOW LOAD, \( p_g \)**: Design ground snow loads.
- **GROUND SNOW LOAD, \( p_{(asd)} \)**: Allowable stress design ground snow loads.

- Added for consistency with ASCE 7-22
- Design GSL is strength-based
- Conversion to ASD GSL as needed

**Notations**

- \( p_{(asd)} \) = Allowable stress design ground snow load.
- \( p_g \) = Ground snow load determined from Figures 1608.2(1) through 1608.2(4) and Table 1608.2.

- Added for consistency with ASCE 7-22
- Strength-based vs ASD ground snow load values
Exception: Construction documents for buildings constructed in accordance with the conventional light-frame construction provisions of Section 2308 shall indicate the following structural design information:

1. Floor and roof dead and live loads.
2. Ground snow load, \( p_g \), and allowable stress design ground snow load, \( p_{g\text{asd}} \).

Construction Documents – General

- Added for IBC provisions still relying on ASD values
- Conversion equation given in IBC
- ASCE Hazard tool also provides ASD values (asce7hazardtool.online)
  - Free resource

Construction Documents – Roof Snow Load Data

- Modified for consistency with ASCE 7-22
- Values vary based on risk category

Deflection Limits

- New footnote
- Reduces strength-based snow loads to ASD levels

Load Combinations – LRFD/Strength Design (SD)

1. \( 1.2D + 1.6L + (0.5L_r \text{ or } 0.35 \text{ or } 0.5R) \) (Eq 2a)
2. \( 1.2D + (1.6L_r \text{ or } 1.05 \text{ or } 1.6R) + (L \text{ or } 0.5W) \) (Eq 3a)
3. \( 1.2D + 1.0(W \text{ or } W_{t}) + L + (0.5L_r \text{ or } 0.35 \text{ or } 0.5R) \) (Eq 4a)
4. \( 1.2D + E_v + E_h + L + 0.15S \) (Eq 6)
Load Combinations – ASD

\[
\begin{align*}
D + (L_r \text{ or } 0.75 \text{ or } R) & \quad \text{(Eq 3a)} \\
D + 0.75L + 0.75(L_r \text{ or } 0.75 \text{ or } R) & \quad \text{(Eq 4a)} \\
D + 0.75L + 0.75(0.6(W \text{ or } W_{2a})) + 0.75(L_r \text{ or } 0.75 \text{ or } R) & \quad \text{(Eq 6a)} \\
\end{align*}
\]

\[
D + 0.525E_v + 0.525E_h + 0.75L + 0.1S & \quad \text{(Eq 9)}
\]

Exceptions:

2. Where the allowable stress design load combinations of ASCE 7 Section 2.4 are used, flat roof snow loads of 30-45 pounds per square foot or less and roof live loads of 30 pounds per square foot or less need not be combined with seismic loads. Where flat roof snow loads exceed 30-45 pounds per square foot, 20\% of the snow load shall be combined with seismic loads.

Load Combinations – Alternative ASD

\[
\begin{align*}
D + L + (L_r \text{ or } 0.75 \text{ or } R) & \quad \text{(Eq 16-1)} \\
D + L + 0.6W + 0.75/2 & \quad \text{(Eq 16-3)} \\
D + L + 0.7S + 0.6W/2 & \quad \text{(Eq 16-4)} \\
D + L + 0.7S + E/1.4 & \quad \text{(Eq 16-5)}
\end{align*}
\]

Exceptions:

2. Flat roof snow loads of 30-45 pounds per square foot or less and roof live loads of 30 pounds per square foot or less need not be combined with seismic loads. Where flat roof snow loads exceed 30-45 pounds per square foot, 20\% of the snow load shall be combined with seismic loads.

Snow Loads – General

Design snow loads shall be determined in accordance with Chapter 7 of ASCE 7, but the design roof load shall be not less than that determined by Section 1607.

Exception: Temporary structures complying with Section 3103.6.1.1.

- Significant changes to loading provisions for temporary structures
  - Reduced ground snow load based on
    - Service life
    - Risk category

Ground Snow Loads

The ground snow loads to be used in determining the design snow loads for roofs shall be determined in accordance with the reliability-targeted (strength based) ground snow load values in Chapter 7 of ASCE 7 or Figures 1608.2(1) and 1608.2(2) through 1608.2(4) for the contiguous United States and Table 1608.2 for Alaska. Site-specific case studies shall be determined in accordance with Chapter 7 of ASCE 7 and shall be approved by the building official. The ground snow loads for sites at elevations above the limits indicated in Figures 1608.2(1) and 1608.2(2) and for all sites within the CS areas shall be approved. Ground snow load determination for such sites shall be based on an extreme value statistical analysis of data available in the vicinity of the site using a value with a 2 percent annual probability of being exceeded (50-year mean recurrence interval). Snow loads are zero for Hawaii, except in mountainous regions as approved by the building official.

- Strength-based ground snow loads
- New maps based on risk category
- ASCE Hazard tool also provides GSL values (asce7hazardtool.online)
  - Based on risk category
  - Free resource
Where required, the ground snow loads, $p_g$, of Figures 1608.2(1) through 1608.2(4) and Table 1608.2 shall be converted to allowable stress design ground snow loads, $p_{g(asd)}$, using Equation 16-17.

$$p_{g(asd)} = 0.7 p_g$$  \hspace{1cm} \text{[Equation 16-17]}

where:
- $p_{g(asd)}$ = Allowable stress design ground snow load.
- $p_g$ = Ground snow load determined from Figures 1608.2(1) through 1608.2(4) and Table 1608.2.

- ASCE Hazard tool also provides ASD values (asce7hazardtool.online)
- Free resource

**EXAMPLE**

**Ground Snow Loads – ASD RC II**

**Ground Snow Conversion**

**EXAMPLE**

**GSL Comparison – IRC 2024/2021**

**EXAMPLE**
Snow Load Provisions NOT Required

- No drift potential
- No unbalanced snow loading
- $p_g < \text{unfactored } L_r$
- $p_g$ & $L_r$ relative to drift location
- As shown graphically

\[ l_u < 100 \text{ ft} \]

\[ p_g < 10 \text{ psf} \]

\[ l_u < 300 \text{ ft} \]

\[ p_g < 5 \text{ psf} \]

4. Ground snow load determination is based on the risk category of the building?
   a) True
   b) False

Winter Wind Parameter, $W_2$

- New factor
- Used for drift height calculations
- Where $V > 10$ mph Oct-Apr (%)
- Hazard tool also provides values

ASCE 7-22 Figure 7.6-1
Susceptible bays of roofs shall be evaluated for ponding instability in accordance with Chapters 7 and 8 of ASCE 7. Ponding instability on roofs shall be evaluated in accordance with ASCE 7.

- Roofs are subject to ponding due to:
  - Primary drains blocked by ice or otherwise
  - Snow melt
  - Rain surcharge

Design Process for Snow Loads

<table>
<thead>
<tr>
<th>Step</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Determine ground snow load, $p_g$ for the site</td>
</tr>
<tr>
<td>2</td>
<td>Determine a flat roof snow load, $p_f$, considering roof exposure and roof thermal condition</td>
</tr>
<tr>
<td>3</td>
<td>Determine minimum snow load for low-slope roofs, $p_m$</td>
</tr>
<tr>
<td>4</td>
<td>Determine sloped roof snow load, $p_s$</td>
</tr>
<tr>
<td>5</td>
<td>Consider partial snow loading, where applicable</td>
</tr>
<tr>
<td>6</td>
<td>Consider unbalanced roof snow loads, where applicable</td>
</tr>
<tr>
<td>7</td>
<td>Consider snow drifts on lower roofs, where applicable</td>
</tr>
<tr>
<td>8</td>
<td>Consider snow drifts adjacent to roof projections and parapets, where applicable</td>
</tr>
<tr>
<td>9</td>
<td>Consider sliding snow, where applicable</td>
</tr>
<tr>
<td>10</td>
<td>Consider rain-on-snow surcharge load, where applicable</td>
</tr>
<tr>
<td>11</td>
<td>Consider ponding loads, where applicable</td>
</tr>
<tr>
<td>12</td>
<td>Consider snow loads on existing roofs, where applicable</td>
</tr>
<tr>
<td>13</td>
<td>Consider snow loads on open-frame equipment structures, where applicable</td>
</tr>
</tbody>
</table>

Flat Roof Snow Loads

$$p_f = 0.7C_eC_tI_p p_g$$

- $p_f$ = ground snow load, psf
- $p_g$ = flat roof snow load
- $C_e$ = basic exposure factor
- $C_t$ = thermal factor
- $I_p$ = importance factor for snow

- Removed – since new maps based on risk category
Exposure Factor, $C_e$

<table>
<thead>
<tr>
<th>Surface Roughness Category</th>
<th>Exposure of Roof</th>
<th>Fully Exposed</th>
<th>Partially Exposed</th>
<th>Sheltered</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>0.9</td>
<td>1.0</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>0.9</td>
<td>1.0</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>

New Table

Thermal Factor, $C_t$

<table>
<thead>
<tr>
<th>Thermal Condition</th>
<th>$C_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unheated, open-air, cold ventilated roofs</td>
<td>1.2</td>
</tr>
<tr>
<td>Freezer building</td>
<td>1.3</td>
</tr>
<tr>
<td>Greenhouses</td>
<td>0.85</td>
</tr>
</tbody>
</table>

New Table

Minimum Snow Loads – Low-sloped Roofs

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>$P_m,_{max}$ (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>25</td>
</tr>
<tr>
<td>II</td>
<td>30</td>
</tr>
<tr>
<td>III</td>
<td>35</td>
</tr>
<tr>
<td>IV</td>
<td>40</td>
</tr>
</tbody>
</table>

$p_B \leq P_m,_{max} \rightarrow P_m = P_B$

$p_B > P_m,_{max} \rightarrow P_m = P_m,_{max}$

Sloped Roof (balanced) Snow Loads, $p_s$

$p_s = C_s P_f$

$C_s = $ slope factor

Revised Ranges

Figure 7.4-1 from Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

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**Roof Surface Friction**

<table>
<thead>
<tr>
<th>Slippery roof surfaces</th>
<th>Metal</th>
<th>Slate</th>
<th>Glass</th>
<th>Bituminous membranes*</th>
<th>Rubber membranes*</th>
<th>Plastic membranes*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not slippery roof surfaces</td>
<td>Asphalt shingles</td>
<td>Wood shingles</td>
<td>Shakes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Slippery = smooth. Membranes with embedded aggregate or mineral granule surface ≠ smooth.

---

**Ice Dams at Eaves**

<table>
<thead>
<tr>
<th>C&lt;sub&gt;r&lt;/sub&gt; for Heated Structures with Unvented Roofs</th>
</tr>
</thead>
<tbody>
<tr>
<td>§ 7.4.4 &amp; F C7.4-1</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

---

**Unbalanced Loading – All Other Gable Roofs**

\[ h_d = \text{drift height} \]
\[ h_d = 1.5 \sqrt{\frac{\left(p_g\right)^{0.5}(W_2)^{0.30}(W_2)^{-0.7}}{\gamma}} \]

- \( \xi = W \)
- \( W \neq W_2 \)
- \( W_2 = \) winter wind parameter
- \( \gamma = \) snow density
  - \( = 0.13p_g + 14 \leq 30 \text{ lb/ft}^3 \)

---

**Drift Height \( (h_d) \) Comparison Based on \( W_2 \)**

- \( W_2 \) for \( \xi \geq 1.1 \)
- \( h_d \) for \( \xi < 1.1 \)

---

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Drifts on Lower Roofs

- Windward and leeward drift loads analyzed separately
- Determine which controls supporting member design
- Higher drift height no longer governs

Drifts – Windward or Leeward

Drift loads need not be considered where \( h_c / h_b < 0.2 \)
- \( h_b = p_c / \text{density (} \gamma \text{)} \)

Windward Drift Length

- \( h_d = \text{drift height} \)
- \( p_d = h_d \times \text{density (} \gamma \text{)} \)

Windward Drifts – Adjacent Roofs

\( h_d = 4h_{d,\text{windward}} \)
Leeward Drifts – Capture Walls

- $h_e = 1.86h_d$

Adapted from ASCE 7-22 Commentary Figure C7.7-2

Leeward Drifts – Adjacent Roofs

Intersecting Drifts – Lower Roofs

- Evaluated at
  - Reentrant corners
  - Parapet wall corners
  - Gable roof and roof step wall
  - Larger of 2 drift depths govern
  - Not superimposed

Design Snow Loads

- Location: Fort Collins, CO
- Surface Roughness: B
  - Sheltered Roof Exposure
- Risk Category: II
- Heated structure
  - Unventilated roof
  - $R = 50$
- Metal roof
Snow and Ice Loads

5. The winter wind parameter, $W_x$, is used to calculate what?
   a) Roof temperature
   b) Drift height
   c) Rafter length
   d) Surface roughness
Snow and Ice Loads

Atmospheric Ice Loads
Nominal ice thickness is now based on risk category

Snow Provisions Change Summary

1. Ground snow loads, $p_g$, are based on building risk category
2. Winter wind parameter, $W_2$, is new for drift height calculations
3. Conversion to allowable stress design ground snow loads, $p_{g(asd)}$, still required for use with some IBC tables
4. Thermal factors, $C_s$, are now given based on ground snow load and insulation R value of the roof

Atmospheric Ice Loads

General. Ice-sensitive structures shall be designed for atmospheric ice loads in accordance with Chapter 10 of ASCE 7.

Exception: Temporary structures complying with Section 3103.6.1.5.

- New exception for temporary structures

Load Combinations

Strength Design
2b. $1.2D + 1.6L + 0.2D_i + 0.35$
4c. $1.2D + L + D_i + W_i + 0.35$
4d. $1.2D + D_i$
5c. $0.9D + D_i + W_i$

ASD
1b. $D + 0.7D_i$
2b. $D + L + 0.7D_i$
3b. $D + 0.7D_i + 0.7W_i + 0.75$
7c. $0.6D + 0.7D_i + 0.7W_i$

$D_i =$ weight of ice
$W_i =$ wind on ice
Definitions and Symbols

**ATMOSPHERIC ICE GEODEATABASE**: The ASCE database (version 2022-1.0) of geocoded nominal ice thickness, concurrent wind, and concurrent temperature data.

\[ t = \text{Nominal ice thickness on a cylinder caused by freezing rain at a height of 33 ft, from Figures 10.4-2 through 10.4-5, for the applicable risk category, in.} \]

- ASCE Hazard tool provides values (asce7hazardtool.online)
  - Based on risk category
  - Free resource

Design Process for Atmospheric Ice Loads

**Step** | **Procedure**
--- | ---
1 | Determine nominal ice thickness, \( t \), concurrent wind speed, \( V_c \), and concurrent temperature for the site from the following:
   - ASCE/SEI Figures 10.4-2 through 10.4-5, 10.5-1, 10.5-2, 10.6-1 and 10.6-2
   - asce7hazardtool.online
   - Site-specific study
2 | Determine height factor, \( f_z \)
3 | Determine site topographic factor, \( K_{zt} \)
4 | Determine design ice thickness, \( t_d \)
5 | Determine ice load, \( D_i \) based on cross-sectional area, \( A_i \), or volume, \( V_i \), of glaze ice
6 | Determine wind velocity pressure, \( q_z \), for concurrent gust speed, \( V_c \)
7 | Determine structure's fundamental natural frequency, \( n_1 \), and corresponding gust-effect factor, \( G \)
8 | Determine wind force coefficients, \( C_f \)
9 | Determine wind-on-ice load, \( W_i \)

Adapted from Structural Load Determination: 2024 IBC and ASCE/SEI 7-22 – McGraw Hill

Ice Load

**Ice Weight Load** The ice load shall be determined using the weight volume or cross-sectional area of glaze ice formed on all exposed surfaces of structural members, guys, components, appurtenances, and cable systems. On structural shapes, prismatic members, and other similar shapes, the cross-sectional area of ice shall be determined by

- Structural shapes, prismatic members, and other similar shapes
  \[ A_i = \frac{\pi t^2}{12} \left( D_i + \frac{t}{2} \right) \text{ (ft$^2$)} \]
- Flat plates and large three-dimensional objects such as domes and spheres
  \[ V_i = \frac{\pi t^2}{12} A_i \text{ (ft$^3$)} \]

- Maps based on risk categories
- Also available from asce7hazardtool.online

Nominal Ice Thickness, \( t \)

The nominal ice thickness is the equivalent radial glaze ice thickness. Figures 10.4-2 through 10.4-5 show the equivalent uniform radial nominal ice thicknesses, \( t \), of ice caused by freezing rain, at a height of 33 ft, over the contiguous 48 states and Alaska for a 500-year mean recurrence interval Risk Categories I, II, III, and IV. Also shown are concurrent 3-s gust wind speeds. Ice thicknesses for Hawaii, and for ice accretions caused by other sources in all regions, shall be obtained from local meteorological studies.
Nominal Ice Thickness, $t$

- $>2,100$ ft special icing regions
- $>6,000$ ft special icing regions

Example: Risk Category IV

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Atmospheric Ice Loads Supplemental Data Request

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Design Ice Thickness for Freezing Rain, $t_d$

The design ice thickness, $t_d$, shall be calculated from Equation (10.4-5).

$$t_d = \Lambda \left( f_z (K_z)_{0.35} \right)$$

- Importance factor dropped
- $f_z$ and $K_z$ unchanged
- $K_z$ = topographic factor from wind loads chapter (10.4.4)
- $f_z$ = height factor (10.4.3)

$$f_z = \begin{cases} \left( \frac{z}{33} \right) & \text{for } 0 \text{ ft} < z \leq 900 \text{ ft} \\ 1.4 & \text{for } z > 900 \text{ ft} \end{cases}$$

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Diameter of Circumscribed Shape, $D_c$

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Snow and Ice Loads

**Wind on Ice-Covered Structures**

Ice accreted on structural members, components, and appurtenances increases the projected area of the structure exposed to wind. The projected area shall be increased by adding $t_d$ to all free edges of the projected area. Wind loads on this increased projected area shall be used in the design of ice-sensitive structures. Figures 10.5-1 through 10.5-6 and 10.5-2 include show 3s gust speeds at 33 ft above grade that are concurrent with the ice loads caused by freezing rain. These gust speeds shall be used with nominal ice thicknesses for all risk categories. Wind loads shall be calculated in accordance with Chapters 26 through 31, as modified by Sections 10.5.1 through 10.5.5.

- Add design ice thickness, $t_d$, to free edges of projected area
- Concurrent gust speeds, $V_c$, for all risk categories
- Calculate wind loads per Chapters 26 - 31

**Gust Speeds, $V_c$, Concurrent with Ice**

![Gust Speeds Map](image)

**Atmospheric Ice Loads on a Tank**

- Material: Reinforced concrete
- Location: Grand Rapids, MI
- Surface Roughness: B
- No hazardous, toxic or explosive materials
- Risk Category II
- Natural fundamental frequency, $n_f > 1Hz$
## Atmospheric Ice Loads Supplemental Data Request

### References

- ASCE 7 §10.5 Concurrent gust speed, $V_c$ (mph)
- ASCE 7 §26.11 Structure’s fundamental natural frequency, $\nu_1$, and corresponding gust-effect factor, $G$
- ASCE 7 §26.10-1 Wind velocity pressure, $q_v$, or $q_h$, (psf)
- ASCE 7 §10.5.1 & Eq 29.4-1 Chimneys, tanks and similar: $W_i = q_v K_v G C_h A_h$
- ASCE 7 §10.5.2 & Eq 29.4-1 Solid freestanding walls and signs: $W_i = q_v K_v G C_h A_h$
- ASCE 7 §10.5.3 & Eq 29.4-1 Open signs and lattice frameworks: $W_i = q_v K_v G C_h A_h$
- ASCE 7 §10.5.4 & Eq 29.4-1 Trusses towers: $W_i = q_v K_v G C_h A_h$
- ASCE 7 §10.5.5 & Eq 29.4-1 Guys and cables: $W_i = q_v K_v G C_h A_h$

### Data

- $q_v = 0.00256 K_v K_1 K_2 V_c^2$ (26.10-1)

## Wind on Ice Loads Supplemental Data Request

### References

- ASCE 7 §10.5 Concurrent gust speed, $V_c$ (mph)
- ASCE 7 §26.11 Structure’s fundamental natural frequency, $\nu_1$, and corresponding gust-effect factor, $G$
- ASCE 7 §26.10-1 Wind velocity pressure, $q_v$, or $q_h$, (psf)

### Data

- $q_v = 0.00256 K_v K_1 K_2 V_c^2$ (26.10-1)

## Atmosphere Ice Loads Supplemental Data Request

### References

- ASCE 7 §10.4.5 Design ice thickness (in.), $t_d$
- ASCE 7 §10.4.3 Height factor, $f_z$
- ASCE 7 §10.4.4 Topographic factor, $K_{zt}$

### Data

- $t_0 = 0.96$
- $t_d = 0.93$
- $f_z = 0.97$
- $K_{zt} = 1.0$

## Example

1. Nominal ice thickness is based on risk category – concurrent gust speed is not.
2. Add design ice thickness, $t_d$, to free edges of projected area to determine wind-on-ice load, $W_i$.
3. MWFRS loads are calculated per Chapters 26 and 29.
4. Wind-on-ice loads, $W_i$, are used concurrently in load combinations with ice weight, $D_i$. 

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6. Concurrent gust speed, $V_c$, is based on risk category of the structure?
   a. True
   b. False

7. Nominal ice thickness, $t$, is based on risk category of the structure?
   a. True
   b. False

Resources
Available for use or that can be used for support or help

Snow Loads Guide
- Ground, flat and sloped roof snow loads
- Partial and unbalanced loads
- Drift on lower roofs and roof projections
- Sliding snow loads
- Rain-on-snow surcharge
- Ponding instability
- Significant changes to ASCE 7-22
  - GSL and drift load provisions
  - Open framed equipment support structures
  - Snow loads for solar paneled roofs
- Worked examples
- FAQs
STRUCTURE Magazine Articles

structuremag.org – Jan, Feb, Mar 2022